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ABSTRACT

From an instructional perspective, it is conceivable that employing an appropriate hypertext architecture should have the advantage of facilitating learning by representing logically the interrelationships between different units of information contained within the hypertext. Furthermore, there would, however, appear to be a sound theoretical rationale for suggesting that the degree to which hypertext based instructional systems facilitate learning will be contingent on an individual's cognitive style. This study investigates the effects of hypertext architecture and cognitive style on learning. Fifty-three participants were assigned to one of three hypertext architectures corresponding to linear, hierarchical and relational structures. Cognitive style was assessed using the Cognitive Styles Index (Allinson and Hayes, 1991). The findings revealed an interaction between cognitive style and hypertext architecture on the recall performance of participants. However, when learning was assessed at a deeper level, no significant effects were observed. Further analysis revealed that concept maps of the hypertext architecture differed between participants in each hypertext condition. The results are discussed in terms of a consideration of individual differences in cognitive style in the design of hypertext instructional systems. (Contains 15 references.) (Author)

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Learning from Hypertext and the Analyst-Intuition Dimension of Cognitive Style

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Abstract: **From an instructional perspective, it is conceivable that employing an appropriate hypertext architecture should have the advantage of facilitating learning by representing logically the interrelationships between different units of information contained within the hypertext. Furthermore, there would however appear to be a sound theoretical rationale for suggesting that the degree to which hypertext based instructional systems facilitate learning will be contingent on an individual's cognitive style. This study aimed to investigate the effects of hypertext architecture and cognitive style on learning. Fifty three participants were assigned to one of three hypertext architectures corresponding to linear, hierarchical and relational structures. Cognitive style was assessed using the Cognitive Styles Index (Allinson and Hayes, 1991). The findings revealed an interaction between cognitive style and hypertext architecture on the recall performance of participants. However, when learning was assessed at a deeper level, no significant effects were observed. Further analysis revealed that concept maps of the hypertext architecture differed between participants in each hypertext condition. The results are discussed in terms of a consideration of individual differences in cognitive style in the design of hypertext instructional systems.**

Introduction

System structure has been found to affect navigational performance within a hypertext environment (McDonald and Stevenson, 1996, 1998), and this in turn has been found to influence learning (Shapiro, 1998; Tripp and Roby, 1990).

The potential benefits of hypertext to learning may also be influenced by employing different hypertext architectures for instruction. There is evidence to suggest that learning performance is enhanced when mixed hypertext architectures are employed (Mohageg, 1992; McDonald and Stevenson, 1998, Shapiro, 1998). In these studies mixed hypertext architectures were hierarchical with lateral links. However, a further question may be posed here, which is whether individual differences between learners can influence performance within particular hypertext architectures.

One individual difference characteristic which would appear to be relevant to learner performance in hypertext, is cognitive style. Field dependence-independence is one of the most extensively researched formulations of cognitive and evolved from Herman Witkin's pioneering work on perception of the upright. With regard to the relationship between cognitive style, hypertext and learning it is likely that the complex hypertext structures, predisposes that individuals possessing a style which facilitates their ability to apprehend such structures when browsing may derive greater benefit in terms of learning from hypertext. Results generally reveal that field independent individuals outperform field-dependents in the recall of verbal information from a hypertext delivery (Lin and Davidson-Shivers, 1996), and also that performance of field independents is superior when using explicitly structured hypertext (Korthauer and Koubek, 1994). However, one alternative explanation for these results is that the Group Embedded Figures Test (GEFT) used to measure field dependence-independence has also been found to be correlated with standard ability tests (Verbon, 1972; McKenna, 1984).

Other studies to date have used different psychometric tests of style in order to test the relationship between style and the effectiveness of instruction delivered via hypertext. For example, Melara (1996) used Kolb's Learning Style Inventory and Beishuizen, Stoutjesdijk and van Putten (1994) and Verhejj, Stoutjesdijk and

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Beishuizen (1996) using a formulation of the deep and surface processors construct. Many of these studies used recall performance as a measure of learning, yet most academic concepts are more complex requiring a level of learning deeper than is demonstrated by mere recall.

This study aims to assess whether different hypertext architectures are more facilitative to individuals with different cognitive styles and employs a psychometrically sound instrument for the assessment of cognitive style. Furthermore, learning in this study is assessed at a deeper level than mere recall of information from the hypertext.

Method

Participants

55 participants took part in this study, 46 male and 9 female undergraduate students, with a mean age of 22.93, an SD of 6.21, minimum age of 19 and maximum age of 47.

Hypertext

The subject matter of the hypertext document was taken from various pieces of historical information and edited so that the names dates and events were altered in order to maintain consistency. Each page of hypertext, typically contained between one and four sentences of information. The document consisted of 64 nodes or pages containing 3388 words.

Three hypertext document was presented as one of three architectures corresponding to linear, hierarchical and relational. A description of each architecture is outlined below. Diagrams of the hypertext architectures employed are shown below in Figs 1 to 3.

In the linear architecture, the hypertext pages were linked such that the user could move only to the next or the previous page. Each page however had a link to the first page, and the first page had a link to the top page of each of the four general sections within the structure. In this way the structure resembled a book structure, in that the user could start at a contents page, and move to the beginning of any chapter, and similarly from the middle of any chapter could jump back to the contents page again (see Figure 1). The linear architecture comprised 66 links between pages.

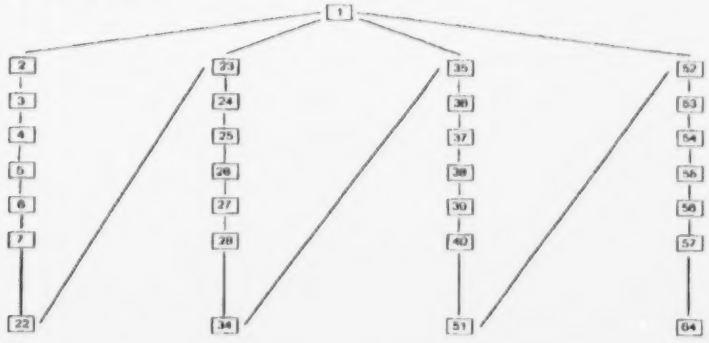

Figure 1: Linear Architecture

The hierarchical architecture was designed so that a user could move from reading a page at one level, down to a page below it in the hierarchy, or back to a page above it in the hierarchy. In this hierarchical architecture, general concepts subsumed more detailed ones. Users could move up and down the hierarchy, exploring subordinate and superordinate relationships. However, no facility was provided for lateral moves (See figure 2). The hierarchical architecture was comprised of 62 links.

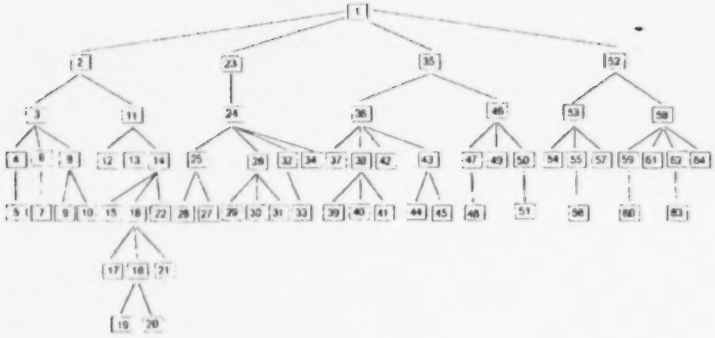

Figure 2: Hierarchical Architecture

The relational architecture was identical to the hierarchical architecture, in that users could move up or down the hierarchy. However, this structure also contained additional links, which meant that the user could move laterally to other locations within the architecture, related by subject matter (see Figure 3). The relational architecture was comprised of 62 links plus a further 32 lateral links.

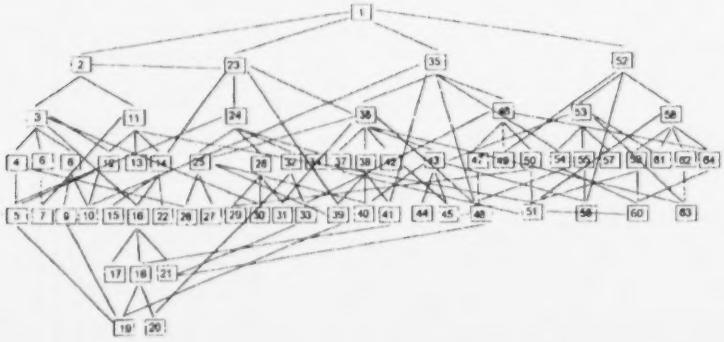

Figure 3: Relational Architecture

Assessment of Cognitive Style (Cognitive Styles Index) (Allinson and Hayes, 1991)

The Cognitive Styles Index is a test of cognitive style developed for large scale use. It determines an individual's position on the analyst-intuitive dimension of cognitive style. Typically analysts are able to apprehend ideas or concepts in parts, but have difficulty integrating such ideas into complete wholes. However, intuitives are able to view ideas as complete wholes, but are unable to separate these ideas into discrete parts. Scores on the CSI can range from 0 up to 76. Analysts can be identified by a low score on this test, while intuitives may be identified by a high score.

Procedure

Participants were assigned to one of the three hypertext architecture conditions, and were asked to read through the hypertext pages in any order they chose, provided that this reading order could be accommodated

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by the hypertext architecture to which they were assigned. They were then tested in three ways. Firstly with ten recall questions, secondly by writing an essay which could be answered from the information in the hypertext and finally by drawing a map of the hypertext architecture they had used.

The recall test was scored by simply adding up the number of correct answers to questions on information within the hypertext. Each essay was assessed in terms of the amount of detail it contained and also how well each participant had integrated the information content in the essay. Maps produced by participants were scored in terms of complexity and density measures. The formula for the calculation of complexity as given by Johnson, Gregory and Smith (1986) is links drawn / nodes drawn. The formula for calculation of density as given by Klein and Cooper (1982) is links / nodes (nodes – 1).

Results

Table 1 displays the results of an analysis of variance for recall questions for architecture and cognitive style, with the means and standard deviations displayed in Table 2. No significant main effects can be observed for architecture and cognitive style, although a significant interaction effect is evident between architecture and cognitive style. Inspection of the table of means reveals variation between cognitive styles within each architecture condition.

Source of Variation	F	p
Architecture	0.61	0.54
Cognitive Style	0.23	0.78
Architecture X Cognitive Style	3.04	0.02

Table 1: Analysis of Variance for Recall for Hypertext Architecture and Cognitive Style (N= 53)

	Mean	SD	Cases
Entire sample	6.18	2.29	55
Relational	6.71	2.31	19
Analyst	5.66	3.01	6
Intermediate	7.78	2.11	7
Intuitive	6.50	1.37	6
Hierarchical	5.91	2.11	18
Analyst	7.58	2.10	6
Intermediate	4.66	2.06	6
Intuitive	5.50	1.04	6
Linear	5.88	2.47	18
Analyst	4.80	1.92	5
Intermediate	5.77	2.53	9
Intuitive	7.50	2.64	4

Table 2: Means and standard deviations for recall scores

Table 3 displays the results of an analysis of variance for essay detail and integration scores for architecture and cognitive style, with the means and standard deviations displayed in Table 4. No significant main effects or interaction effects can be observed for architecture or cognitive style for each of these variables.

Source of Variation	F	p
Detail		
Architecture	0.21	0.80
Cognitive Style	0.00	0.99
Architecture X Cognitive Style	0.83	0.51
Integration		
Architecture	0.13	0.87
Cognitive Style	0.60	0.54
Architecture X Cognitive Style	1.33	0.27

Table 3: Analysis of Variance for Detail and Integration Scores for Hypertext Architecture and Cognitive Style (N= 50)

	Mean Detail	SD	Mean Integration	SD	Cases	
Entire sample	64.36		46.02	37.50	23.28	50
Relational	66.79		50.05	35.26	20.10	19
Analyst	87.83		75.62	38.33	25.82	6
Intermediate	63.29		35.94	39.29	18.58	7
Intuitive	49.83		29.23	27.50	16.36	6
Hierarchical	57.81		38.00	37.81	22.87	16
Analyst	56.67		51.58	36.67	22.95	6
Intermediate	55.50		30.92	25.00	14.72	4
Intuitive	60.50		32.90	47.50	25.84	6
Linear	68.27		50.72	40.00	28.35	15
Analyst	46.00		49.34	23.75	23.23	4
Intermediate	71.00		44.91	42.86	27.21	7
Intuitive	85.75		66.70	51.25	34.49	4

Table 4: Means and standard deviations for detail and integration scores

Table 5 displays the results of an analysis of variance for essay detail and integration scores for architecture and cognitive style, with the means and standard deviations displayed in Table 6. A significant main effect can be observed for architecture on the density, $F(2,35) = 4.43$, $p = 0.01$. Inspection of the means scores in Table 6 reveals that participants performing in the relational architecture condition score highest on density scores. Tukey's test of post-hoc comparisons, reveals significant differences in complexity scores between participants in the relational and hierarchical architecture conditions ($p<.01$), however, no differences were observed between relational and linear conditions or between hierarchical and linear conditions for complexity. For density scores, the main effect for architecture is approaching significance, $F(2,35) = 2.80$, $p = 0.07$. Finally, an interaction effect approaching significance between architecture and cognitive style can be observed $F(4,35) = 2.24$, $p = 0.08$.

Source of Variation	F	p
Complexity		
Architecture	4.43	0.01
Cognitive Style	0.64	0.53
Architecture X Cognitive Style	0.96	0.43
Density		
Architecture	2.80	0.07
Cognitive Style	0.91	0.40
Architecture X Cognitive Style	2.24	0.08

Table 5: Analysis of Variance for Complexity and Density Scores for Hypertext Architecture and Cognitive Style (N= 44)

	Mean Complex	SD	Mean Density	SD	Cases
Entire sample	1.22	0.35	0.20	0.31	44
Relational	1.40	0.31	0.30	0.52	13
Analyst	1.45	0.35	0.18	0.18	4
Intermediate	1.24	0.22	0.16	0.11	6
Intuitive	1.65	0.31	0.75	1.08	3
Hierarchical	1.03	0.19	0.08	0.04	14
Analyst	1.07	0.18	0.09	0.03	5
Intermediate	0.95	0.09	0.09	0.05	6
Intuitive	1.13	0.33	0.06	0.02	3
Linear	1.22	0.41	0.23	0.20	17
Analyst	1.14	0.24	0.17	0.12	5
Intermediate	1.32	0.54	0.32	0.25	8
Intuitive	1.18	0.32	0.12	0.07	4

Table 6: Means and standard deviations for complexity and density scores

Discussion

This study examined several issues regarding cognitive style and learning from hypertext. Firstly, a significant interaction was observed between cognitive style and hypertext architecture for recall questions. While it is conceded that recall does not represent an effective measure of learning, the results go some way to suggesting that individuals possessing different cognitive styles learn more efficiently from certain hypertext architectures. This finding is in accord with the cognitive styles matching hypothesis.

The cognitive style matching hypothesis essentially suggests that when the cognitive styles of the system and the user are matched, then the amount of learning will be improved. An illustration of the interaction between a teacher's and learner's cognitive styles is given in the diagram below. (see figure 4).

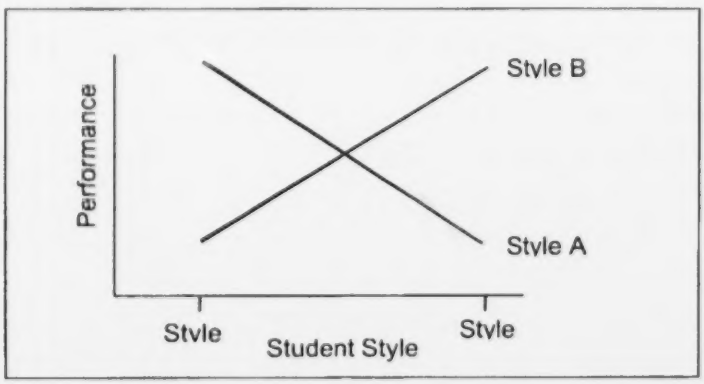

Figure 4: Theoretical interaction between learner's and teacher's cognitive styles

In this respect, hypertext appears to offer promise to such a matching hypothesis, as the architecture may be designed with consideration to the cognitive style of the user.

No differences were found on assessment of detail and integration in the essay question for hypertext architecture or cognitive style. This somewhat calls into question the previous results, although it is equally possible that the scoring system employed for the essay question needs further refinement.

A significant effect was observed for complexity scores for architecture, with participants in the relational architecture producing significantly more complex maps than those performing in the other two conditions. This may be accounted for by the fact that the relational condition had more hypertext links than

each of the other two conditions. Finally differences were observed for density scores between architectures and furthermore an interaction effect was also observed here. As density scores approach 1 the map's density increases as it approaches optimal connectivity. In this study map density was used as an indication of the degree to which participants had integrated the individual concepts within the subject domain. However, the effects here are only approaching significance.

At least two important methodological points need to be considered in future studies. Firstly, it is possible that individuals may engage differently with certain types of information depending on their cognitive styles. Therefore a different type of information content may possibly give different results. Therefore the type of information featured in the hypertext also needs to be considered. Secondly, in this investigation, learning was measured by scoring essays for level of detail. It is relevant also to consider other methods of learning in future studies.

Conclusion

It is tentatively suggested that the results revealed in this study may be applied in the context of matching hypertext architecture to the cognitive style of the user in order to facilitate more effective learning. This therefore has important implications for e-learning as it is possible that individuals may benefit by using hypertext architectures designed to take account of their particular cognitive styles. Hypertext would appear to offer great promise to such a matching, as these systems may be designed with consideration to the cognitive style of the user, and their ability to effectively apprehend the structure of the system and also to perceive their correct orientation.

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